JOHNS HOPKINS
Center for Environmental
& Applied Fluid Mechanics

Weekly CEAFM Seminar: Fall 2012

Date: **Friday, September 14, 2012**

Time: 11:00 AM

Location: Gilman 50 (Marjorie M. Fisher Hall)

Speaker: **Dr. Richard J.A.M. Stevens** (MechE | Johns Hopkins University)

Title: **"*Rayleigh-Bénard Turbulence*"**

Abstract

Turbulence is seen as one of the last outstanding unsolved problems in classical physics. In the last century, great minds as Heisenberg, von Weizsäcker, Kolmogorov, Prandtl, and G.I. Taylor had worked on it, and Einstein put his last postdoc Bob Kraichnan on the subject of turbulence – a task which Kraichnan never finished. The rapid development of experimental and numerical techniques in this area and the growth of computing power create a lot of activity on turbulence research. In turbulence problems encountered in the real world the influence of walls is very important and one of the classical systems to study concepts in fluid dynamics is the Rayleigh-Bénard (RB) system, i.e. the buoyancy driven flow of a fluid heated from below and cooled from above. Also from an applied viewpoint, thermally driven flows are of utmost importance. Examples are thermal convection in the atmosphere, in the ocean, or in process technology.

Rotating turbulent flow is of utmost importance to optimize industrial applications such as the efficient separation of carbon dioxide (CO_2) from nitrogen in the emission gases of conventional carbon-based power plants to enable long term CO_2 storage or the separation of CO_2 from natural methane gas. In both cases the method of choice is pressurization and cooling down of the gas mixture so that finally CO_2 condensates into droplets and can be separated in so-called rotational phase separators. Due to the droplet condensation, considerable heat transfers emerge in this process which is strongly affected by rotation.

In this presentation experimental I will present experimental, numerical and theoretical results on RB convection. Simulations and experiments on RB convection are complementary. In accurate experimental measurements of the heat transfer a completely isolated system is needed. Therefore, one cannot visualize the flow while the heat transfer is measured. On the positive side, in experiments one can obtain very high R*a* numbers and longtime averaging. In direct numerical simulations (DNS), on the other hand, one can simultaneously measure the heat transfer while the complete flow field is available for analysis. Unfortunately, up to recently, there was a major disagreement between experimental and numerical measurements of the heat transfer. We showed that this disagreement was due to insufficient numerical resolution in the simulations. Our new high resolution simulations agree excellently with the experimental result. In addition, we showed some very unexpected transitions between different turbulent states in RB convection, which will be discussed in detail. We find that very small changes in the control parameters can completely change the flow structure or can drastically alter the flow dynamics that are observed.